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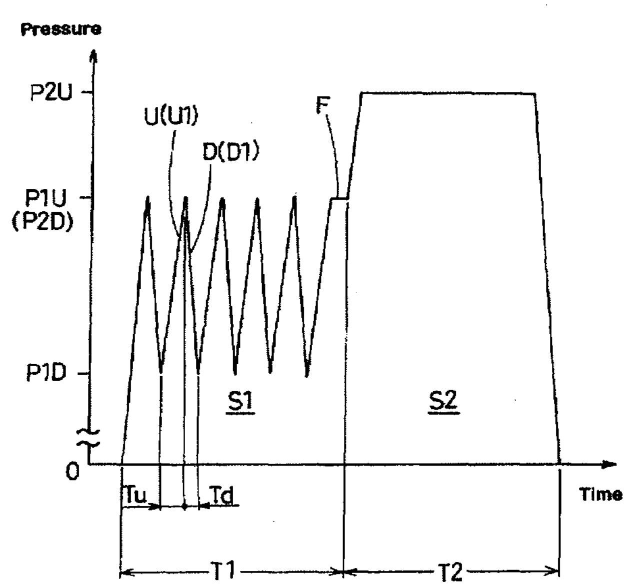
(54) Method of moulding an elastomeric article

(57) A method of moulding an elastomeric article comprises: putting an elastomeric article (J) in a mould (3); softening the elastomeric article in the mould by heating the elastomeric article; pressing the elastomeric article against the mould by pressurising an inside (7) of the elastomeric article by letting a fluid therein; and changing the pressure of said fluid in a short cycle so as to beat the elastomeric article against the mould repeatedly.

Fig.1



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Description

[0001] The present invention relates to a method of moulding an elastomeric article.

[0002] When a pneumatic tyre which is a typical elastomeric article is moulded or vulcanised, conventionally, a green tyre is first built and it is heated in a mould by steam under a constant pressure P1U for a predetermined time T1 and then the inside thereof is pressurised by a gas at a constant high pressure P2U for a predetermined T2 as shown in Fig.5. By pressurising the inside, the softened rubber is pressed against the inner surface of the mould.

[0003] However, when the inner surface of the mould is provided with relatively deep dents or hollows for example as a negative tyre tread pattern, it is difficult to fill all the comers of the hollows with rubber, and defective moulding such as rubber bareness on the outer surface of the tyre is liable to occur.

[0004] In general, in order to prevent rubber bareness, a large number of vent holes are provided in the dents. Accordingly, a large number of spews of rubber are formed on the moulded article. It takes a lot of time and labour to remove the spews. The time and labour may be reduced if the number of the vent holes is decreased, but rubber bareness then increases.

[0005] It is therefore, an object of the present invention to provide a method of moulding an elastomeric article, in which the pushing of the elastomer into dents or hollows on the inner surface of the mould is improved to prevent the occurrence of bareness of elastomer on the surface of the moulded elastomeric article and also to decrease the number of vent holes.

[0006] According to the present invention, a method of moulding an elastomeric article comprises putting an elastomeric article in a mould, softening the elastomeric article in the mould by heating the elastomeric article, pressing the elastomeric article against the mould by pressurising an inside of the elastomeric article by letting a fluid therein, and changing the pressure of said fluid in a short cycle so as to beat the elastomeric article against the mould repeatedly.

[0007] The cyclic pressure change must be carried out after the elastomeric article is softened at latest. Each cycle of the pressure change is made up of a decompression step in which the pressure decreases from a higher pressure to a lower pressure, and a subsequent repressurising step in which the pressure increases from the lower pressure to the higher pressure. The number of cycles, namely the number of the repressurising or decompression steps is at least two but at most about 50, usually at most about 30, preferably at most 20. The duration time of one decompression step is not more than about 60 seconds, and the duration time of one repressurising step is also not more than about 60 seconds. If these duration times are longer than 60 seconds, the beating effect is ineffective, and it is difficult to prevent the bareness of elastomer.

[0008] Taking a method of vulcanising a pneumatic tyre for example, embodiments of the present invention will now be described in detail in conjunction with the accompanying drawings, in which:

Fig. 1 is a time chart showing an example of the pressure change according to the present invention;
Fig.2 is a time chart showing another example of the pressure change according to the present invention;
Fig.3 is a schematic cross sectional view of a mould for vulcanising a pneumatic tyre showing an example of the piping for the heating medium and pressurising medium;
Fig.4 is a diagram showing another example of the piping for the heating medium and pressurising medium; and
Fig.5 is a time chart showing a pressure change employed in the under-mentioned comparison test.

Embodiments (Tyre vulcanising method)

[0009] Embodiments (I) and (II) according to the present invention will now be described in detail. In each embodiment the elastomeric article is a pneumatic tyre J, and the method of vulcanising the pneumatic tyre comprises a process S 1 of heating the tyre J up to vulcanising temperature by putting a heating medium 2A inside the tyre J which tyre is disposed in a mould 3, and a process S2 of pressing the softened tyre J against the inner surface of the mould 3 by pressurising the inside of the tyre by a pressurising medium 2B in the inside of the tyre J.

[0010] The heating medium 2A is a high-temperature gaseous material having a high heat capacity. The temperature thereof is higher than the vulcanising temperature which is usually about 140 degrees C. For instance, the heating medium 2A is steam which is substantially saturated. The temperature thereof is about 200 degrees C. The delivery pressure PA thereof is about 1500 kPa.

[0011] The pressurising medium 2B is a high-pressure inert gas having a low heat capacity. If it is necessary to prevent cooling down of the tyre, the temperature thereof is preferably the substantially the same or is higher than the vulcanising temperature. However, as the heat capacity is low, the temperature may be lower than the vulcanising temperature. So if further heat for the full vulcanisation is not necessary, the temperature may be set at a low temperature of about 40 or 50 degrees for example. The delivery pressure PB of the inert gas is higher than the delivery pressure PA of the heating medium 2A. For instance, the pressurising medium 2B is nitrogen gas, its temperature is about 160 degrees C, and its delivery pressure PB is about 2100 kPa.

[0012] In the case of a tyre for passenger cars or the like, the duration time T1 of the heating process S1 is usually about 3 to about 4 minutes, and the duration time T2 of the pressurising process S2 is usually about 6 to about 9 minutes.
[0013] Hereinafter, the heating medium 2A and pressurising medium 2B are generically called "fluid 2".
[0014] According to the present invention, after the tyre is softened at the latest, the pressure of the fluid 2 in the inside of the tyre is changed repeatedly at a short time cycle to press the tyre against the mould.
[0015] Fig. 1 is a chart showing a change in the pressure inside of the tyre. In this example, the pressure is cyclically changed during the heating process S1.
[0016] Fig.2 is a chart showing another example of change in pressure of the inside of the tyre. In this example, the pressure is cyclically changed during the pressurising process S2.

Embodiment (I)

[0017] In Fig. 1, the pressure is first increased from the initial pressure of 0 kPa to a maximum pressure P1U. The maximum pressure P1U is that in the heating process not in the pressurising process. This is the initial pressurising step. Thereafter, a decompression step D1 in which the pressure decrease from the maximum pressure P1U to a lower pressure P1D, and a repressurising step U1 in which the pressure increases from the lower pressure P1D to the maximum pressure P1U are alternately carried out.
[0018] The maximum pressure P1U is equal to the delivery pressure PA of the heating medium 2A. The lower pressure P1D is set in a range of not less than 1/2 times the maximum pressure P1U. However, the lower pressure P1D may be set in a range of less than 1/2 times the maximum pressure P1U.
[0019] In this embodiment, the duration time Td of one decompression step D1 is set in a range of not more than about 10 seconds, preferably in a range of from almost 0 (practically about 0.5 sec.) to about 4 seconds. Also, the duration time Tu of one repressurising step U1 is set in a range of not more than about 10 seconds, preferably in a range of from almost 0 (practically about 0.5 sec.) to about 4 seconds.
[0020] The number of cycles, namely, the number Nd of the decompression steps D1 or the number Nu of the repressurising steps U1 is set in a range of from 2 to about 20. In the case of a usual tread pattern (not a deep pattern), five to seven cycles may be enough for preventing the rubber bareness. Therefore, the number of cycles is preferably in a range of from 2 to 10. If the number Nu, Nd is too large, the total time T1 of the heating process S1 becomes excessively long, and there is a tendency toward over cure.
[0021] The heating process S 1 may be provided before, during or preferably after the decompression/repressurising cycles by a constant pressure step F in which the pressure is held constant.
[0022] In the pressurising process S2, on the other hand, the pressure is first increased to a maximum pressure P2U from an initial pressure in a short time. Then, the pressure is kept constant (the maximum pressure P2U) until the tyre is vulcanised. Here, the initial pressure is the maximum pressure P1U in the heating process. The maximum pressure P2U is that in the pressurising process, which is equal to the delivery pressure PB of the pressurising medium 2B (2100 kPa in this example).

Embodiment (II)

[0023] In Fig.2, the heating process S1 is carried out substantially under constant pressure. That is, the pressure is increased in a short time from the initial pressure of 0 kPa to the maximum pressure P1U in the heating process. Under the maximum pressure P1U (constant pressure), heating is continued for a predetermined time after the temperature of the tyre reaches the vulcanising temperature.
[0024] In the pressurising process S2, on the other hand, the pressure is first increased to the maximum pressure P2U from the initial pressure which is equal to the maximum pressure P1U in the heating process. Thereafter, a decompression step D2 in which the pressure is decreased from the maximum pressure P2U to a lower pressure P2D, and a repressurising step U2 in which the pressure is increased from the lower pressure P2D to the maximum pressure P2U are alternately carried out. The duration time Td of one decompression step D2, the duration time Tu of one repressurising step U2, and the number of cycles of the pressure change may be set in the same way as in the former embodiment. In this embodiment, it is preferable that the pressurising process S2 includes a constant pressure step after the decompression/repressurising cycles.
[0025] As another example of the tyre vulcanising method, it is also possible to change the pressure in both of the heating process S 1 and pressurising process S2.

Tyre mould

[0026] As shown in Fig.3, the above-mentioned tyre mould 3 has a vulcanising cavity 7 or an annular hollow in which a green tyre is put. The tyre mould 3 is, for example, a split mould which is split into an upper mould piece 3U and an

lower mould piece 3L disposed coaxially of the tyre around a central machinery 6. The central machinery 6 is provided with two ports 9 and 10 for the passage of fluid 2. The ports 9 and 10 open towards the vulcanising cavity 7. In this example, in order to avoid direct contact of the fluid 2 with the tyre J, an expandable bladder 11 made of a rubber compound is provided therebetween. The above-mentioned heating medium 2A is led to the vulcanising cavity 7 from a heating medium supply source 4 through heating medium piping 12A. The pressurising medium 2B is led to the vulcanising cavity 7 from a pressurising medium supply source 5 through pressurising medium piping 12B.

[0027] In Fig.3, the heating medium piping 12A extending from the heating medium supply source 4 is connected to the port 9, and the pressurising medium piping 12B extending from the pressurising medium supply source 5 is also connected to the same port 9. But, in order to exclusively allow one of the heating medium and pressurising medium to flow into the inside of the mould, each piping 12A, 12B is provided with a valve 32. That is, if one of them is opened, the other is closed. On the other hand, release piping 30A for the heating medium (steam) and release piping 30B for the pressurising medium (nitrogen gas) are connected to the other port 10. Similarly, each piping 30A, 30B is provided with a valve 32. At the time of releasing the heating medium, the valve on the release piping 30A is opened but the other is closed. At the time of releasing the pressurising medium, the valve on the release piping 30B is opened but the other is closed. The other end of the release piping 30B is connected to a suction pump 31 in order to exhaust the gas in order to contract the bladder 11 when the tyre vulcanisation is finished, and also in order to collect the gas. It is also possible to connect the other end of the release piping 30A to a suction pump in order to collect the steam and its heat. The opening and closing of these valves 32 are executed by a programmable controller 17. The above-mentioned cyclic change in the pressure is made by the opening and closing of the valves 32.

[0028] In Fig.4 which shows another example of the fluid circuit, the release piping 30A and the release piping 30B are connected to the port 10 as shown in Fig.3. But, the heating medium piping 12A (in case of Fig.1) or the pressurising medium piping 12B (in case of Fig.2) and a further release piping 19 are connected to the port 9 through a switching valve 16 and the above-mentioned valve 32. The remainder, that is, the pressurising medium piping 12B (in case of Fig. 1) or the heating medium piping 12A (in case of Fig.2) is connected to the port 9 through the valve 32 in the same way as in Fig.3. The opening and closing of the valves 32 and the switching of the valve 16 are executed by a programmable controller 17. In this example, the above-mentioned cyclic change in the pressure is made by the switching of the valve 16, namely, the switching of the connection of the port 9 between the medium piping (12A, 12B) and the release piping 19.

[0029] The programmable controller 17 operates the valves 32, 16 according to the outputs of various sensors such as a sensor 15 for the pressure in the vulcanising cavity 7, a sensor for the temperature and the like, and an internal clock, following a stored program which realises the timetable shown in Fig.1 or Fig.2. The temperature sensor 15 is disposed on the mould and used to detect conditions that the pressure reaches to a) the maximum pressure P1U or the lower pressure P1D in case of Fig. 1, or b) the maximum pressure P2U or the lower pressure P2D in case of Fig.2.

[0030] By the way, in any embodiment, the processes for releasing the pressurising medium, taking the tyre from the mould, etc. follow after the pressurising process S2.

Comparison Test

[0031] Green tyres (Tyre size 225/40ZR18) were made and vulcanised using the same mould but different time charts shown in Table 1. Visual external examination on rubber bareness on the outer surface of the tyre was made and the tyre was cut-open for inspection for adhesive failure between laminated layers, namely the inner liner and carcass ply, etc. due to residual air therebetween were made to obtain the rate of defective mouldings. The results are also show in Table 1.

Table 1

Moulding	Ref.	Ex.1	Ex.2
Pressure chart type	Fig.5	Fig.1	Fig.1
Heating process S 1			
Total time T1	3'00	5'30"	3'00"
Pressure	constant	variable	variable
Maximum pressure P1U (kPa)	1500	1500	1500
Lower pressure P1D (kPa)	--	500	1000
Pressurising steps			

Table 1 (continued)

Moulding	Ref.	Ex.1	Ex.2
Pressure chart type	Fig.5	Fig.1	Fig.1
Heating process S 1			
Number Nu *1	1	6	7
Time Tu (sec.)	30	30	2
Decompression steps			
Number Nd	0	5	6
Time Td (sec.)	--	30	2
Heating medium	steam	steam	steam
Temperature (deg.C)	200	200	200
Delivery pressure PA (kPa)	1500	1500	1500
Pressurising process S2			
Total time T2	5'00"	3'00"	3'00"
Pressure	constant	constant	constant
Maximum pressure P2U (kPa)	2100	2100	2100
Pressurising steps			
Number Nu * 1	1	1	1
Time Tu (sec.)	15	15	15
Decompression steps			
Number Nd *2	0	0	0
Time Td (sec.)	--	--	--
Pressurising medium	N	N	N
Temperature (deg.C)	40	40	40
Delivery pressure PB (kPa)	2100	2100	2100
Rate of defective mouldings (%)	20	0	0

*1) including the initial pressurising step
*2) not including the last decompression step

[0032] As described above, in the tyre vulcanising methods according to the present invention, the short-cycle pressure change beat or press the elastomer repeatedly against the inside of the mould. As a result, the elastomer was pushed in to the dents or hollows on the inner surface of the mould, and at the same time, the air trapped between the elastomeric article and the mould was removed. Therefore, the occurrence of bareness of the elastomeric material was effectively prevented. Further, the air trapped between laminated layers such as an inner liner and a carcass ply during tyre building processes were also removed to prevent adhesive failures.
[0033] As described above, the present invention may be suitably applied to a pneumatic tyre as a vulcanising method therefor.
[0034] However it can also be applied to elastomeric articles having unevenness on the outer surface and a hollow which the fluid is let in to pressurise or vulcanise the article.

Claims

1. A method of moulding an elastomeric article comprising putting an elastomeric article (J) in a mould (3), softening the elastomeric article in the mould by heating the elastomeric article, pressing the elastomeric article against the mould by pressurising an inside of the elastomeric article by letting a fluid (2B) therein, **characterised by** changing the pressure of said fluid in a short cycle so as to repeatedly press or beat the elastomeric article against the mould.

2. A method according to claim 1, **characterised in that** one cycle of the change in the pressure comprises a decrease

of short duration of not more than 60 seconds and an increase of short duration of not more than 60 seconds.

3. A method according to claim 1, **characterised in that** the number of cycles of the change in the pressure is at least two.

4. A method according to claim 1, **characterised in that** the number of cycles of the change in the pressure is at least two but at most fifty.

5. A method according to claim 1, **characterised in that** the number of cycles of the change in the pressure is at least two but at most twenty.

6. A method according to claim 1, **characterised in that** the number of cycles of the change in the pressure is at least two but at most ten.

7. A method according to claim 1, **characterised in that** said elastomeric article is a pneumatic tyre.

8. A method according to claim 7, **characterised in that** one cycle of the change in the pressure comprises a decrease of short duration of not more than 10 seconds and an increase of short duration of not more than 10 seconds.

9. A method according to claim 1, **characterised in that** said fluid is a heating medium which is let in the inside of the elastomeric article to heat the elastomeric article.

10. A method according to claim 1, **characterised in that** said fluid is a heating medium which is let in the inside of the elastomeric article to heat the elastomeric article, and thereafter a pressurising medium is let in the inside of the elastomeric article to press the elastomeric article against the mould.

11. A method according to claim 10, **characterised in that** the heating medium is a gas having a high heat capacity, and the pressurising medium is an inert gas having a heat capacity lower than the heat capacity of the heating medium.

12. A method according to claim 9 or 10, **characterised in that** in the process of heating the elastomeric article by the heating medium, after the cyclic change in the pressure of the heating medium is made, the pressure is kept substantially constant for a certain length of time.

Fig.1

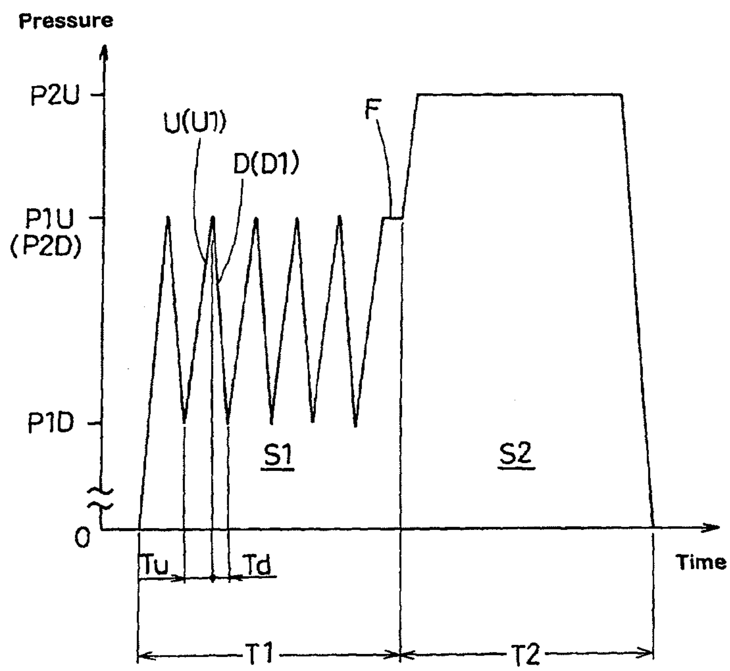

Fig.2

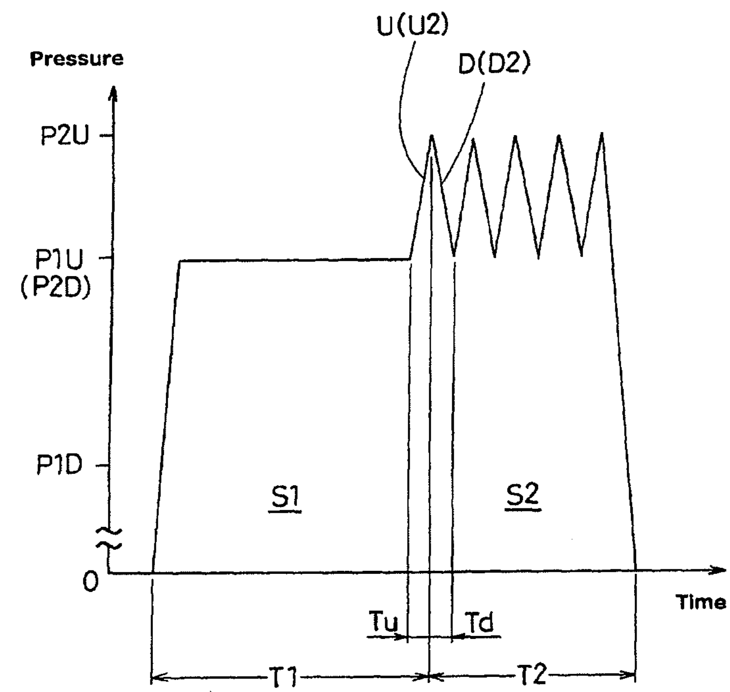

Fig.3

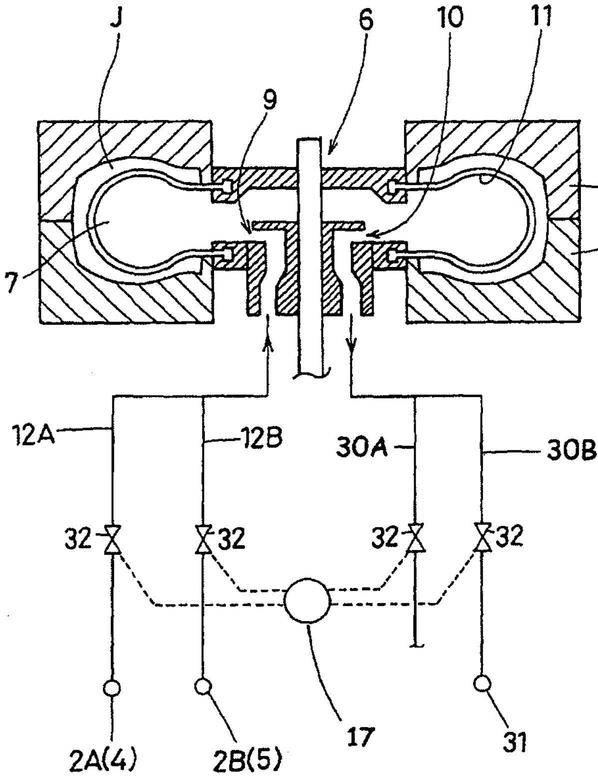

Fig.4

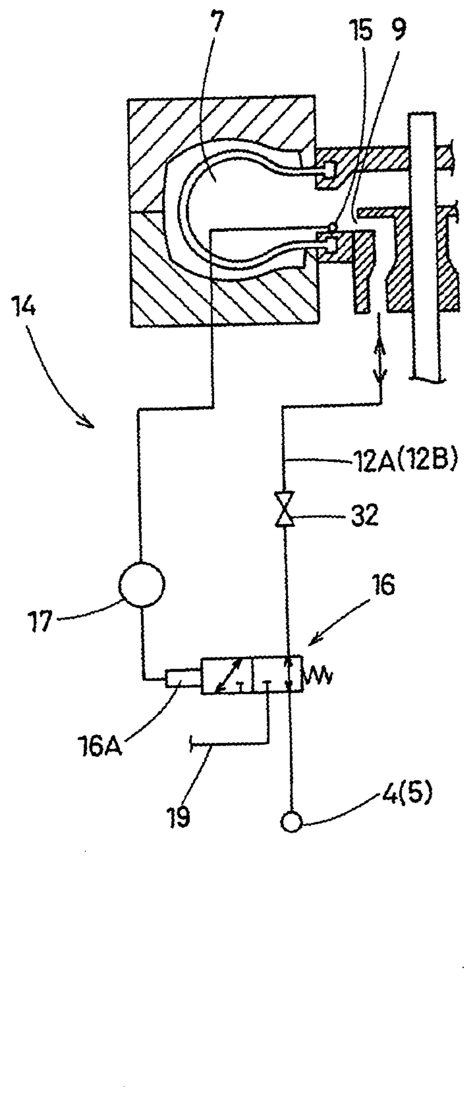

Fig.5